Programme	BS Solid State Physics	Course Code	SSP-308	Credit Hours	3 (2-1)
Course Title	**Experimental Techniques in Solid State Physics**				

Course Introduction

This course introduces students to the experimental methods and techniques used in the study of solid state physics. The course covers the principles behind various characterization techniques, their applications in investigating the properties of solid materials, and the interpretation of experimental data. Students will gain hands-on experience with instrumentation and data analysis, preparing them for research and professional work in materials science, condensed matter physics, and related fields.

Learning Outcomes

By the end of this course, students will:

1. Understand the principles and applications of various experimental techniques used in solid state physics.
2. Gain proficiency in the use of instruments and equipment for material characterization.
3. Learn to analyze and interpret experimental data related to the structural, electronic, magnetic, and optical properties of solids.
4. Develop the ability to design and conduct experiments, and to communicate scientific results effectively.
5. Prepare for advanced studies or careers in experimental solid state physics and materials science.

	Course Content	**Assignments/Readings**
Week 1	**Unit-I** 1.1 Introduction to Experimental Techniques in Solid State Physics 1.1.1 Overview of experimental solid state physics 1.1.2 Importance of experimental techniques in understanding material properties 1.1.3 Safety procedures and best practices in the laboratory	What is experimental solid state physics?
Week 2	**Unit-II** 2.1 X-Ray Diffraction (XRD) 2.1.1 Basic principles of X-ray diffraction	What is the basic principle of XRD?

	2.1.2 Bragg's Law and the determination of crystal structures	
Week 3	**Unit-III** 3.1 Powder X-ray diffraction and its applications in material identification 3.1.1 Single-crystal X-ray diffraction 3.1.2 Data analysis: indexing, lattice parameter determination, and phase identification	Differentiate various types of XRD
Week 4	**Unit-IV** 4.1 Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) 4.1.1 Principles of electron microscopy: electron beam interactions with matter 4.1.2 SEM: imaging, electron backscatter diffraction (EBSD), and energy-dispersive X-ray spectroscopy (EDS)	What is the principle of SEM and TEM?
Week 5	**Unit-V** 5.1 TEM: diffraction, high-resolution imaging, and selected area electron diffraction (SAED) 5.1.1 Sample preparation techniques for SEM and TEM 5.1.2 Applications of SEM and TEM in materials characterization	Review related articles
Week 6	**Unit-VI** 6.1 Atomic Force Microscopy (AFM) 6.1.1 Principles of AFM: force interactions and cantilever deflection 6.1.2 Modes of operation: contact, tapping, and non-contact modes	What is AFM and for which purpose it is used?
Week 7	**Unit-VII** 7.1 Imaging and measuring surface topography at the nanoscale 7.1.1 Force spectroscopy and mechanical property measurements 7.1.2 Applications of AFM in surface science and nanotechnology	

Week 8	Mid Term Exams	
Week 9	**Unit-VIII** 8.1 Vibrational Spectroscopy: Infrared (IR) and Raman Spectroscopy 8.1.1 Basic principles of vibrational spectroscopy 8.1.2 IR spectroscopy: absorption, reflection, and transmission modes	What is spectroscopy?
Week 10	**Unit-IX** 9.1 Raman spectroscopy: inelastic scattering of light and vibrational modes 9.1.1 Applications in identifying molecular vibrations, chemical bonding, and crystal structures 9.1.2 Complementary use of IR and Raman spectroscopy in material analysis	Review some papers and articles
Week 11	**Unit-X** 10.1 Magnetometry and Magnetic Measurements 10.1.1 Principles of magnetometry: measurement of magnetic moments and susceptibility 10.1.2 Types of magnetometers: vibrating sample magnetometer (VSM), superconducting quantum interference device (SQUID) 10.1.3 Measurement of hysteresis loops, coercivity, and remanence 10.1.4 Temperature dependence of magnetic properties: Curie and Néel temperatures 10.1.5 Applications in studying magnetic materials and phenomena	How VSM works?
Week 12	**Unit-XI** 11.1 Electrical and Thermal Transport Measurements 11.1.1 Four-point probe method for measuring electrical resistivity and conductivity 11.1.2 Hall effect measurements: carrier concentration and mobility	Which type of data we can access from four-point probe?

Week 13	**Unit-XII** 12.1 Seebeck effect and thermal conductivity measurements 12.1.1 Low-temperature measurements using cryostats and liquid helium 12.1.2 Applications in semiconductors, metals, and thermoelectric materials	Read books
Week 14	**Unit-XIII** 13.1 Optical Spectroscopy and Photoluminescence 13.1.1 Principles of optical spectroscopy: absorption, emission, and reflectance 13.1.2 Photoluminescence (PL) spectroscopy: excitons and recombination processes 13.1.3 UV-Vis-NIR spectroscopy and bandgap determination 13.1.4 Time-resolved spectroscopy and lifetime measurements 13.1.5 Applications in semiconductors, quantum dots, and optoelectronic materials	What is PL?
Week 15	**Unit-XIV** 14.1 Experimental Data Analysis and Interpretation 14.1.1 Data collection, noise reduction, and error analysis 14.1.2 Fitting models to experimental data (e.g., least squares fitting) 14.1.3 Interpretation of experimental results in the context of material properties 14.1.4 Writing scientific reports and presenting data 14.1.5 Case studies of experimental research in solid state physics	Case study

Week 16	Final Term Exams	

Textbooks and Reading Material

1. "Elements of X-Ray Diffraction" by B.D. Cullity and S.R. Stock
2. "Introduction to Solid State Physics" by Charles Kittel
3. "Scanning Electron Microscopy and X-Ray Microanalysis" by Joseph Goldstein et al.
4. "Atomic Force Microscopy: Understanding Basic Modes and Advanced Applications" by Greg Haugstad
5. "Magnetic Measurements: Techniques and Applications" by R.A. Dunlap
6. "Fundamentals of Molecular Spectroscopy" by C.N. Banwell and E.M. McCash
7. "Solid State Physics: An Introduction" by Philip Hofmann

Teaching Learning Strategies

1. Course Teaching
2. Presentations
3. Quiz

Assignments: Types and Number with Calendar

1.
2.
3.
4.

Assessment

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
2.	Formative Assessment	25%	Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
3.	Final Assessment	40%	Written Examination at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.